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DAILY ACTIVITY OF POLISH HOLSTEIN-FRIESIAN COWS DEPENDING ON VARIABLE HOUSING CONDITIONS DURING LACTATION

AKTYWNOŚĆ DOBOWA KRÓW RASY PHF W ZALEŻNOŚCI OD ZMIENNYCH WARUNKÓW UTRZYMANIA W TRAKCIE LAKTACJI

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Streszczenie. Celem badań była analiza aktywności krów rasy PHF w zależności od warunków utrzymania w trakcie laktacji, związanych z krótkotrwałym (trwającym 30 dni) zmniejszaniem im powierzchni bytowej. Materiał do badań stanowiły dwie grupy (po 25 krów) utrzymywane w sektorach z wybiegiem lub bez niego, poddawane okresowemu (trwającemu 30 dni) zagęszczeniu oraz jedna grupa o zmniejszającej się obsadzie. Wszystkie zwierzęta wyposażono w zamocowane na tylnych nogach pedometry, z których uzyskiwano informacje o aktywności wyrażonej w krokach na godzinę, częstotliwości odpoczynku (krotność na dzień), długości pojedynczego odpoczynku (min), łącznym czasie spoczynku (min). Analiza aktywności badanych grup przed wprowadzeniem zmian obsady zwierząt wykazała, że w grupie krów bez dostępu do wybiegu najaktywniejsze okazały się krowy w IV laktacji (175,59 kroku/h), oraz pierwiastki (147,09 kroku/h). Krowy pierwiastki odpoczywały najczęściej spośród badanych zwierząt (14,14), charakteryzował je również najdłuższy łączny czas odpoczynku (588,73 min). W grupie z dostępem do wybiegu największą aktywność, potwierdzoną statystycznie, wykazywały krowy pierwiastki (132,18 kroku/h) a najmniejszą – krowy w trakcie IV laktacji (108,92 kroku/h). Równocześnie krowy w IV laktacji cechowały się najmniejszą częstotliwością odpoczynku (8,41) oraz łącznym czasem odpoczynku wynoszącym 525,16 min, przy największej długości pojedynczego odpoczynku (74,91 min). Z powodu pierwszego wzrostu zagęszczenia stwierdzono bardzo dużą aktywność grupy krów bez dostępu do wybiegu (133,65 kroku/h), natomiast krowy z dostępem do wybiegu zmniejszyły swoją aktywność. Kolejne zagęszczanie badanych grup skutkowało zwiększeniem aktywności krów bez dostępu do wybiegu, co związane było z rosnącym stresem, natomiast krowy z dostępem do wybiegu nie zareagowały zwiększoną aktywnością, wydłużył się jednak czas ich pojedynczego spoczynku (61,16 min), przy spadku jego częstotliwości. Ostatecznie łączny czas odpoczynku był i tak krótszy niż w grupie bez dostępu do wybiegu. W grupie bez wybiegu odpoczynki stawały się rzadsze, ale jednocześnie dłuższe (59,91 min), co mogło być spowodowane problemem ze znalezieniem miejsca do odpoczynku. We wszystkich grupach badawczych łączny czas odpoczynku skrócił się do niespotykanego wcześniej czasu poniżej 490 min.

Key words: daily activity, animal welfare, dairy cows.
Słowa kluczowe: aktywność dobowa, dobrostan, bydło mleczne.

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INTRODUCTION

According to Broom (1991), the welfare of an animal is its state as regards its attempts to cope with its environment. Guthrie (1935) listed four requirements that have to be met for the animal to cope with adverse environmental conditions. First of all, the animal must have a behavioural pattern to be able to cope with a given situation. Second, stress situation must be close to a possible solution. If one of these requirements is not fully met, the animal will be unable to learn to cope with a given problem. Thus, the animal's inactivity in response to a certain factor may indicate that the animal cannot cope with this problem despite its attempts, thereby showing the behaviour of "learned helplessness" (Alloy and Seligman 1979). A cow spends 4 to 6 hours eating and 0.5 hour drinking. These activities are cyclical and each of these periods lasts from 0.5 to 1 hour for eating and 3 minutes for drinking. A cow rests between 10 and 14 hours each day, showing the lowest activity from midnight to 6:00 am and from 3:00 to 6:00 pm (Wójcik 2014). According to Grant (2007), cows spend 8–12% of the time moving and standing, 11–15% being milked, 20–25% feeding and drinking, and most of the time (40–50%) lying down. This is consistent with the results of other studies, which consider lying as the priority for cows, which spend from 12 to 14 hours on this activity (DeVries et al. 2005; Reinholz-Trojan 2007; Czerniawska-Piątkowska et al. 2008; Solan and Jóźwik 2009; Guliński et al. 2014). According to Jørgensen et al. (2007), restricted access to feed as a result of crowding in the pen leads to behavioural changes.

A study with goats found reduced amount of time spent eating (by as much as 80% for subordinate animals), increased frequency of aggressive behaviour (such as forcing other animals to move by intruding their territory, also by pushing and hitting). There were also increases in the time subordinate animals waited for access to feed. At the same time, overstocking (insufficient number of boxes for the animals) may adversely affect the herd by disrupting their feeding and social behaviour. This situation may lead to changes in the circadian rhythm (Reinholz-Trojan 2007) and in the frequency of aggressive behaviours (Solan and Jóźwik 2009; Keyserlingk et al. 2009). Crowding may induce diseases and cause unfavourable changes in physiological parameters (Reinholz-Trojan 2007). Locomotor activity of animals is determined by multiple factors such as the number of lactations, animal's age, level of milk production (Yániz et al. 2006), mobility score (Reader et al. 2011), and the type and number of lying stalls available. Research showed that individually housed cows in pens with a mattress flooring laid down 4.2 h longer than animals housed in tie-stalls on a concrete floor (Haley et al. 2000). Tie-stall cows showed longer individual standing and lying bouts and thus their activity was reduced, which is evidence that animals are more reluctant to change position in the tie-stall system (Haley et al. 2000). This may be due to the fact that animals are less willing to stand up when housed on hard flooring (concrete), because they rest all of their body weight on their knees when standing up (Metzner 1978). Short-term increases in the activity of animals are most often, but now always, caused by stress situations (Medrano-Galarza et al. 2012). One example is when feed is administered in the barn. Barn-housed cows were found to change their behavioural pattern when eating. Previously cows made their feed intake rhythm dependent on time of the day (Albright 1993), now it is connected with the time at which fresh feed is provided (DeVries et al. 2005). Cows

also increase their activity when they leave their group and feel threatened (Abramowicz et al. 2014). In this situation they become more fearful and less tolerant of stress (Reinholz--Trojan 2007). They are also more active in the morning than in the afternoon or evening (Wójcik and Rudziński 2014; Wójcik and Olszewski 2015).

The aim of the study was to analyse the activity of Polish Holstein-Friesian cows depending on variable housing conditions during lactation, associated with short-term reduction in the living area.

MATERIAL AND METHODS

The study was conducted in 2015–2016 at the Experimental Station of the National Research Institute of Animal Production in Chorzelów using a group of Polish Holstein--Friesian (PHF) cows. Animals in different experimental groups were kept in a free-stall system in sections of the same dimensions. Daily milking was performed in a herringbone milking parlour and TMR-based feeding was the same for all animals. The study used three main groups of experimental animals, each having at least 25 animals:

- group I – 25 cows housed in sections without outdoor access and subjected to temporary crowding – initial area 3.80 m^2/animal;
- group II – 25 cows housed in sections with outdoor access and subjected to temporary crowding – initial area 7.74 m^2/animal;
- group II – 31 cows housed in sections with outdoor access and used for crowding groups I and II – initial area 3.80 m^2/animal;

All animals were fitted with pedometers on the hind legs, which recorded data on daily activity at each milking. The data included activity (steps/hour), resting frequency (times per day), resting bout duration (minutes), and total resting time (minutes). As part of the study, stocking density was changed in different experimental periods of 30 days according to the scheme shown below.

Table 1. Changes in stocking density and living area in different study groups depending on experimental period
Tabela 1. Zmiany obsady zwierząt i powierzchni bytowej w poszczególnych grupach badawczych w zależności od okresu doświadczalnego

Experimental period Okres badań	Group – Grupa					
	I		II		III	
	n	m^2/head m^2/szt.	n	m^2/head m^2/szt.	n	m^2/head m^2/szt.
Comparative period Okres porównawczy	25	3.80	25	7.74	31	6.24
Experimental period I Okres doświadczalny I	30	3.16	30	6.45	21	9.21
Experimental period II Okres doświadczalny II	35	2.71	35	5.35	11	17.60

The study determined the relationship of normal and above-normal number (crowding) of cows per section with their activity traits. Daily activity time budgets in different study periods were determined. Resting frequency, resting time, and total resting time were also analysed.

The results were statistically analysed using SAS software, which accounted for the studied parameters and the determinants of the results obtained. Because the groups differed in the number of animals, LSM procedure of SAS 9.3 was used in the statistical analyses. The following model was used in statistical analysis of the measurements:

$$Y_{ijklm} = \mu + a_i + b_j + c_k + d_l + e_{ijklm}$$

where:

Y_{ijklm} – analysed trait,
μ – overall mean,
a_i – effect of factor (calving number I–VI),
b_j – effect of factor (group I–III),
c_k – effect of factor (study period I–II),
d_l – effect of factor (cow's sire),
e_{ijklm} – random error.

RESULTS AND DISCUSSION

The analysis of activity parameters for group I is presented in Table 2.

Table 2. General characteristics of daily activity parameters in experimental group I in different lactations according to the Afifarm system
Tabela 2. Charakterystyka ogólna cech aktywności dobowej w grupie doświadczalnej I w poszczególnych laktacjach, wg systemu Afifarm

No. of lactation Numer laktacji	Activity Aktywność [steps/h – kroki/h] $\overline{X}$ /sd	Resting frequency Częstotliwość odpoczynku [n] $\overline{X}$ /sd	Resting bout duration Czas pojedynczego odpoczynku [min] $\overline{X}$ /sd	Total resting time Łączny czas odpoczynku [min] $\overline{X}$ /sd
I n = 651	147.09^{AC} 43.19	14.14^{AB} 5.55	46.73^{ABC} 20.86	588.73^{ABC} 172.62
II n = 1416	132.06^{AC} 61.20	10.72^{AC} 4.45	57.57^{AD} 26.30	556.09^{A} 190.31
III n = 865	105.20^{AB} 30.56	8.90^{AD} 4.20	69.87^{AEF} 31.76	549.81^{BD} 203.13
IV n = 117	175.59^{AC} 50.36	6.78^{BCE} 2.38	58.51^{BE} 25.03	368.01^{AE} 125.73
V n = 101	94.39^{C} 32.31	9.37^{AE} 4.00	56.10^{CF} 15.61	494.05^{AD} 177.70
VI n = 143	82.70^{AB} 14.10	12.38^{BCDE} 5.19	44.94^{DEF} 12.50	525.02^{CE} 175.37

In column for: – W obrębie kolumny dla: AA – P ≤ 0.01, aa – P ≤ 0.05.

The most active were fourth lactation cows (175.59 steps/h) followed by primiparous cows (147.09 steps/h). The differences between these two groups and the other lactation groups were statistically significant. Interestingly, despite the fact that the cows from these two groups were characterized by high activity, they differed markedly in the other types of behaviour, in particular resting frequency (P ≤ 0.01). Westin et al. (2016) reported the activity

results using simple linear regression. The coefficients showed that primiparous cows (reference group) in relation to cows beyond third lactation differed in resting frequency by 0.9 lying bout in favour of the primiparous cows. These findings are supported by Wójcik and Olszewski (2015). In our study, fourth lactation cows showed lowest resting frequency (6.78 resting bouts/day) and shortest total resting time (368.01 min), whereas primiparous cows rested most frequently out of the studied animals (14.14) and were characterized by the longest total resting time (588.73 min). Their resting bout duration was in between that of fourth lactation cows (69.87 min) and sixth lactation cows (44.94 min).

Data on the daily activity of cows from group II are shown in Table 3. This activity was significantly highest in primiparous cows (132.18 steps/h) and lowest in fourth lactation cows (108.92 steps/h). At the same time, fourth lactation cows were characterized by lowest resting frequency (8.41) and total resting time (525.16 min), and longest resting bout (74.91 min). The differences, most of which were highly significant, are shown in the table. Higher activity of young animals was also reported in a study by Wójcik and Olszewski (2015), where heifers exhibited higher stress levels than cows. This translated into a greater number of steps per hour. In the morning (7.00–9.00) these differences averaged from 23 ($P \leq 0.05$) to 70 steps ($P \leq 0.01$) and in the afternoon (18.00–20.00) from 35 to 104 steps/h ($P \leq 0.01$). This relationship is confirmed by Vasseur et al. (2012), who compared the activity of cows based on lactation stage, multiparity or primiparity, and housing system (tie stalls or free stalls). The results showed an inversely proportional relationship between the duration and frequency of resting bout. This pattern was not observed in multiparous cows under free-stall housing. Fifth lactation cows, despite showing one of the shortest resting bouts on average (63.28 min), were characterized by the highest resting frequency (12.05). In this way they achieved the longest total resting time (725.17 min), which was statistically confirmed.

Table 3. General characteristics of daily activity parameters in experimental group II in different lactations according to the Afifarm system
Tabela 3. Charakterystyka ogólna cech aktywności dobowej w grupie doświadczalnej II w poszczególnych laktacjach, wg systemu Afifarm

No. of lactation Numer laktacji	Activity Aktywność [steps/h – kroki/h] $\overline{X}$ /sd	Resting frequency Częstotliwość odpoczynku [n] $\overline{X}$ /sd	Resting bout duration Czas pojedynczego odpoczynku [min] $\overline{X}$ /sd	Total resting time Łączny czas odpoczynku [min] $\overline{X}$ /sd
I n = 849	132.18^{ABC} 38.15	10.44^{AB} 4.02	66.79^{A} 33.12	626.93^{Aa} 196.40
II n = 971	113,25^{A} 36.92	11.49^{B} 4.38	60.39^{AB} 19.89	646.81^{Ba} 191.31
III n = 1051	121.21^{AD} 16.28	9.72^{AB} 4.09	65.68^{BC} 26.08	577.03^{AB} 186.02
IV n = 304	108.92^{BD} 32.08	8.41^{AB} 4.87	74.91^{ACD} 34.38	525.16^{AB} 213.68
V n = 141	114.39^{C} 34.29	12.05^{A} 4.01	63.28^{D} 18.63	725.17^{AB} 192.39

Explanations see Table 2 – Objaśnienia zob. tab. 2.

The data on activity traits of cows from group III are presented in Table 4. The lowest activity of 97.53 steps/h was characteristic of fourth lactation cows (P ≤ 0.01). Matthews et al. (2012) point out that cows with lower BCS are more active because they ingest more dry matter. Therefore, they spend less time lying. Resting frequency (7.61) and total resting time (440.52 min) for fourth lactation cows were among the lowest in group III. Oldest (sixth lactation) cows spent most time resting (635.08 min) and most frequently showed their willingness to rest (12.98), thereby devoting least time per resting bout (51.60 min). Also primiparous cows (the youngest group under analysis) showed one of the highest resting frequencies (11.34) with the shortest resting bout possible (57.37 min). This is supported by the study of Wójcik and Olszewski (2015), where the highest resting frequency and at the same time the shortest resting bout duration were observed for heifers with increased daily activity. In our study, the differences found between lactations were statistically confirmed, as shown in Table 4. Westin et al. (2016) reported that oldest (third and higher lactation) cows spent most, and primiparous cows least time resting. The difference between these groups, expressed as a linear regression coefficient, was 40.4.

Table 4. General characteristics of daily activity parameters in experimental group III in different lactations according to the Afifarm system
Tabela 4. Charakterystyka ogólna cech aktywności dobowej w grupie doświadczalnej III w poszczególnych laktacjach, wg systemu Afifarm

No. of lactation Numer laktacji	Activity Aktywność [steps/h – kroki/h] $\overline{X}$ /sd	Resting frequency Częstotliwość odpoczynku [n] $\overline{X}$ /sd	Resting bout duration Czas pojedynczego odpoczynku [min] $\overline{X}$ /sd	Total resting time Łączny czas odpoczynku [min] $\overline{X}$ /sd
I n = 1661	128.32^{AB} 64.55	11.34^{ABC} 5.00	57.37^{ABC} 24.22	570.37^{Aa} 160.50
II n = 777	130.56^{CDE} 44.84	9.28^{Aa} 4.20	65.74^{A} 24.42	555.86^{Ba} 199,58
III n = 814	101.66^{BDEFa} 34.60	8.73^{BCa} 4.71	80.85^{ADE} 45.15	583.85^{B} 233,04
IV n = 424	97.53^{AC} 35.78	7.61^{AC} 2.84	62.57^{BD} 21.62	440.52^{AB} 126.18
V n = 129	111.35^{AFa} 54.12	9.28^{C} 4.20	67.79^{CE} 37.11	550.34^{A} 209.49
VI n = 126	115.23^{BCE} 30.71	12.98^{AC} 5.09	51.60^{ABC} 14.72	635.08^{AB} 217.04

Explanations see Table 2 – Objaśnienia zob. tab. 2.

The activity analysis of cows during the comparison period shows several significant relationships and differences between the studied groups (Table 5). By far the highest activity (126.34 steps/h) was shown by animals without outdoor access (group I). This group was characterized by the shortest total resting time (555.22 min), which resulted from the shortest resting bout duration (58.78 min), but also by high resting frequency (10.70). The differences were significant (P ≤ 0.01). Szewczyk and Pawłowska (2015) compared the activity of conventionally raised cows (without access to outdoor areas and pasture) and two

groups of cows from an organic farm, where one group grazed pasture and another was fed forage. They found the highest activity in pastured cows (137.73 min/d), followed by organically farmed cows with outdoor access (125.62 min/d) and cows from the conventional farm (122.92 min/d). The differences were statistically significant. The other two groups with outdoor access, which exhibited lower daily activity, spent more time resting (which they devoted to digestion and chewing), and therefore were characterized by higher daily milk production. Statistical differences between the groups are given in the table.

Table 5. Characteristics of daily activity of the cows in different study groups during the comparison period
Tabela 5. Charakterystyka aktywności dobowej krów w poszczególnych grupach badawczych w okresie porównawczym

Study group Grupa badawcza [n]	Activity Aktywność [steps/h – kroki/h] $\overline{X}$ /sd	Resting frequency Częstotliwość odpoczynku [n] $\overline{X}$ /sd	Resting bout duration Czas pojedynczego odpoczynku [min] $\overline{X}$ /sd	Total resting time Łączny czas odpoczynku [min] $\overline{X}$ /sd
I n = 2181	126.34^{Aa} 54.19	10.70^{A} 4.75	58.79^{AB} 27.40	555.22^{A} 186.18
II n = 2176	122.82^{Ba} 42.52	10.57^{B} 4.28	64.29^{A} 26.17	616.53^{AB} 191.59
III n = 2559	118.48^{AB} 52.72	9.92^{AB} 4.70	65.53^{B} 31.40	564.30^{B} 191.60

Explanations see Table 2 – Objaśnienia zob. tab. 2.

Due to the increase in stocking density and thus reduced welfare, group I showed very high activity (133.65 steps/h) in relation to the other study groups (Table 6).

Table 6. Characteristics of daily activity of the cows in different study groups during the experimental period I
Tabela 6. Charakterystyka aktywności dobowej krów w poszczególnych grupach badawczych w okresie doświadczalnym I

Study group Grupa badawcza [n]	Activity Aktywność [steps/h – kroki/h] $\overline{X}$ /sd	Resting frequency Częstotliwość odpoczynku [n] $\overline{X}$ /sd	Resting bout duration Czas pojedynczego odpoczynku [min] $\overline{X}$ /sd	Total resting time Łączny czas odpoczynku [min] $\overline{X}$ /sd
I n = 1028	133.65^{A} 53.15	11.88^{AB} 5.69	55.94^{AB} 26.98	576.07^{Aa} 206.47
II n = 951	114.01^{A} 38.08	10.59^{A} 4.76	68.98^{A} 30.81	642.47^{AB} 207.81
III n = 357	104.31^{A} 46.27	10.62^{B} 4.96	66.62^{B} 36.13	601.77^{Ba} 187.27

Explanations see Table 2 – Objaśnienia zob. tab. 2.

Phillips (2002) observed that if the amount of floor space per animal drops below 4–5 m^2, it is likely that during the first few days the activity of cows will increase because animals compete for space. Already during the comparison period these cows exhibited higher activity than cows from groups II and III, but during this period the difference has widened.

Cows from this group rested frequently but for short periods, which resulted in the lowest total resting time (P ≤ 0.01). Cows from groups II and III reduced their activity (P ≤ 0.01). In relation to the comparison period, animals from group III, which had better welfare after 10 animals were moved to groups I and II, showed the lowest activity (104.31 steps/h). However, resting bout duration and total resting time were not the longest, which could be due to the frequency of shorter rest. The indicators of resting frequency and resting bout duration in group II were at a similar level as in group III, largely because the cows had access to outdoor areas, which compensated for poorer welfare. However, the differences were observed in total resting time (P ≤ 0.01).

During the second experimental period (Table 7), the greatest difference in activity appeared between group I and groups II and III (P ≤ 0.01).

Table 7. Characteristics of daily activity of the cows in different study groups during the experimental period II
Tabela 7. Charakterystyka aktywności dobowej krów w poszczególnych grupach badawczych w okresie doświadczalnym II

Study group Grupa badawcza [n]	Activity Aktywność [steps/h – kroki/h] $\overline{X}$ /sd	Resting frequency Częstotliwość odpoczynku [n] $\overline{X}$ /sd	Resting bout duration Czas pojedynczego odpoczynku [min] $\overline{X}$ /sd	Total resting time Łączny czas odpoczynku [min] $\overline{X}$ /sd
I n = 312	123.99^{AB} 58.69	8.08^{A} 3.13	59.82 26.51	435.23^{A} 132.03
II n = 362	109.60^{A} 33.36	7.67^{B} 2.73	61.16^{a} 28.21	418.49^{B} 98.50
III n = 143	110.77^{B} 45.26	9.52^{AB} 3.83	55.04^{a} 20.51	483.54^{AB} 166.75

Explanations see Table 2 – Objaśnienia zob. tab. 2.

Cows from the crowded group without outdoor access considerably increased their activity, which was due to stress. Group II, which had outdoor access, did not respond with increased activity after stocking density was increased, but resting bout duration increased (61.16 min) while resting frequency decreased. As a result, total resting time was shorter than in groups III and I anyway (P ≤ 0.01). Telezhenko et al. (2012), who investigated the effect of crowding as well as pen size on the activity of animals, observed a different relationship. In both the small and large pen, after stocking density was increased, resting frequency increased while resting duration decreased. In all the study groups, total resting time dropped to an unprecedented time of less than 490 min. In relation to the previous experimental periods, all the parameters of resting frequency and resting bout duration deteriorated. In the study by Krawczel et al. (2012), a density of 131% reduced both resting frequency and resting bout duration as well as total resting time (when compared to the reference group). However, when stocking density increased by another 11%, resting frequency continued to decrease, but total resting time and resting bout duration increased in relation to the previous group. The activity of animals, presented in the table, was lower than during the comparison period and similar to that during the first experimental period.

The results for activity of animals from experimental group I are given in Table 8.

Juxtaposition of the comparison period with the first experimental period shows there are no major changes in the activity of animals. Resting bout duration became slightly shorter (by 4 min), and along with an increase in resting frequency from 10.64 to 12.45, it resulted in the total resting time being longer by 41.75 min. Within-trait differences between the studied groups were significant at $P \leq 0.01$. In the second experimental period, total resting time decreased considerably to reach 423.03 min, despite the fact that the animals were less active (122.05 steps/h). Rests were less frequent but at the same time longer (59.91 min), which could be due to problems finding a place to rest. The findings of Krawczel et al. (2012) are consistent with our results. With an increase in stocking density from 100 to 142%, resting frequency decreased from 11.7 to 10.7, and at the same time resting bout duration increased from 67 to 69.3 min.

Table 8. General characteristics of daily activity of the cows in experimental group I in different experimental periods
Tabela 8. Charakterystyka ogólna aktywności dobowej w grupie doświadczalnej I w poszczególnych okresach doświadczalnych

Experimental period Okres badań [n]	Activity Aktywność [steps/h – kroki/h] $\bar{X}$ /sd	Resting frequency Częstotliwość odpoczynku [n] $\bar{X}$ /sd	Resting bout duration Czas pojedynczego odpoczynku [min] $\bar{X}$ /sd	Total resting time Łączny czas odpoczynku [min] $\bar{X}$ /sd
Comparative Porównawczy n = 2221	126.85 54.59	10.64^{A} 4.74	58.84^{A} 27.39	552.48^{A} 186.23
Experimental I Doświadczalny I n = 790	126.50 44.24	12.45^{A} 5.65	54.85^{AB} 27.28	594.53^{A} 204.08
Experimental II Doświadczalny II n = 282	122.05 59.53	7.85^{A} 3.01	59.91^{B} 27.28	423.03^{A} 128.82

Explanations see Table 2 – Objaśnienia zob. tab. 2.

The activity analysis of cows from the experimental group II is presented in Table 9. Clear changes were found in daily activity of the cows, which were twice crowded with other animals. In the first experimental period, when the first group of cows was introduced, the activity of animals was found to decline ($P \leq 0.01$). Resting frequency as well as total resting time decreased during the second experimental period, reaching 7.36 and 421.33 min, respectively. The highest resting frequency (11.15) with comparable resting bout durations were shown by animals from the first experimental period, and thus they obtained the highest value of total resting time (674.55 min). Differences between the studied groups were significant within all the traits studied.

The activity of cows from group III (Table 10) was subject to small but statistically significant fluctuations. However, the observed changes were smallest compared to the other experimental groups (I–II) because the animals which increased the stocking density of groups I and II were taken from group III. Thus, this group had the largest area per animal. As for the other experimental groups (I–II), average resting time of the studied cows was shortest in the second experimental period (478.59 min) despite the fact that stocking density in this group decreased in relation to the other groups.

Table 9. General characteristics of daily activity of the cows in experimental group II in different experimental periods
Tabela 9. Charakterystyka ogólna aktywności dobowej w grupie doświadczalnej II w poszczególnych okresach doświadczalnych

Experimental period Okres badań [n]	Activity Aktywność [steps/h – kroki/h] $\overline{X}$ /sd	Resting frequency Częstotliwość odpoczynku [n] $\overline{X}$ /sd	Resting bout duration Czas pojedynczego odpoczynku [min] $\overline{X}$ /sd	Total resting time Łączny czas odpoczynku [min] $\overline{X}$ /sd
Comparative Porównawczy n = 2214	123.63^{AB} 43.69	10.53^{A} 4.28	64.26^{A} 26.27	613.42^{A} 192.24
Experimental I Doświadczalny I n = 815	114.21^{B} 34.75	11.15^{A} 4.56	67.78^{A} 29.18	674.55^{A} 198.30
Experimental II Doświadczalny II n = 288	111.76^{A} 30.87	7.36^{A} 2.57	64.12 29.94	421.33^{A} 101.83

Explanations see Table 2 – Objaśnienia zob. tab. 2.

Table 10. General characteristics of daily activity of the cows in experimental group II in different experimental periods
Tabela 10. Charakterystyka ogólna aktywności dobowej w grupie doświadczalnej III w poszczególnych okresach doświadczalnych

Experimental period Okres badań [n]	Activity Aktywność [steps/h – kroki/h] $\overline{X}$ /sd	Resting frequency Częstotliwość odpoczynku [n] $\overline{X}$ /sd	Resting bout duration Czas pojedynczego odpoczynku [min] $\overline{X}$ /sd	Total resting time Łączny czas odpoczynku [min] $\overline{X}$ /sd
Comparative Porównawczy n = 2609	118.82^{a} 52.76	9.89^{A} 4.69	65.42^{a} 31.35	562.27^{A} 191.67
Experimental I Doświadczalny I n = 956	121.09^{ab} 57.84	10.67^{A} 5.33	63.46 32.04	574.91^{B} 197.15
Experimental II Doświadczalny II n = 367	114.30^{b} 43.97	8.75^{A} 3.66	61.69^{a} 27.17	478.59^{AB} 146.29

Explanations see Table 2 – Objaśnienia zob. tab. 2.

After reducing stocking density to 82%, Wang et al. (2016) observed average resting time to increase from 11.79 to 12.19 h/day. However, the differences were not significant. No such changes were observed in our results as shown in the tables. It is possible that the obtained results were due to other unaccounted factors such as climatic conditions, because animals reduce the time spent lying when they feel high temperatures (Cook et al. 2007). Resting bout duration was subject to a downward trend in the subsequent periods. Differences between the studied periods with regard to the analysed trait are presented in Tables 10.

CONCLUSION

Our study demonstrated that even a short deterioration in welfare may influence the behaviour of animals, cause considerable stress, and make them overactive.

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Yàniz J.L., Santolariaa P., Giribetb A., López-Gatius F. 2006. Factors affecting walking activity at estrus during postpartum period and subsequent fertility in dairy cows. Theriogenology 66, 1943–1950.

Abstract. The aim of the study was to analyse the activity of Polish Holstein-Friesian cows depending on variable housing conditions during lactation, associated with short-term (30-day) reduction in the living area. The study used two groups of cows (25 animals per group) housed in sections with or without an outdoor area and subjected to temporary (30-day) crowding as well as one group of cows subjected to decreasing stocking density. All animals were fitted with pedometers on the hind legs, which recorded data on activity (steps/hour), resting frequency (times per day), resting bout duration (minutes), and total resting time (minutes). Activity analysis of the groups performed before the change in stocking density showed that in the group of cows without outdoor access, fourth lactation cows (175.59 steps/h) and primiparous cows were the most active (147.09 steps/h). Primiparous cows rested most frequently (14.14) and showed longest total resting time (588.73 min). In the group with outdoor access, significantly highest activity was shown by primiparous cows (132.18 steps/h) and lowest activity by fourth lactation cows (108.92 steps/h). Fourth lactation cows were also characterized by lowest resting frequency (8.41) and lowest total resting time (525.16 min), as well as longest resting bout (74.91 min). Following the first increase in stocking density, the group of cows without outdoor access showed very high activity (133.65 steps/h), and the cows with outdoor access reduced their activity. The next increase in stocking density caused the confined cows to increase their activity, which was associated with increasing stress, while the group of cows with outdoor access did not respond with higher activity but the duration of resting bout increased (61.16 min) and its frequency decreased. As a result, total resting time was shorter than in the group without outdoor access. In the group without outdoor access, rests were less frequent but longer (59.91 min), which could be due to the difficulty finding a place to rest. In all the study groups, total resting time decreased to an unprecedented time of less than 490 min.